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**On the Classification of Butterflies, with special reference to the position of the EQUITES or Swallow-tails.**

BY SAMUEL H. SCUDDER.

The family groups into which butterflies should be primarily divided have been variously given, all the way from two to sixteen. As the structure of the different stages becomes better known, there is an increasing proof of the intimate connection of many of the groups formerly believed very distinct, and it is generally conceded by the better class of recent writers, that there are only about half-a-dozen principal groups. My own study of their structure and transformation leads me to divide them primarily into four families, viz. :

The brush-footed butterflies or NYMPHALES (= Nymphalidæ Bates.)\*

The gossamer-winged butterflies or RURALES (= Erycinidæ et Lycænidæ Bates.)

The typical butterflies † or PAPILIONIDES (= Papilionidæ Bates.)

The skippers or URBICOLÆ (= Hesperidæ Bates.)

The family nature of the last group has never been questioned by any who look upon the butterflies as composed of more than one family; indeed their distinction from the others is so marked that some have considered the remainder of the butterflies their equivalent in value; that is, they divide all butterflies into only two families or tribes. ‡ Doubtless, these skippers first separated from the common stock and never developed to a high degree, since they still remain by far the lowest of the group and are in many points more closely allied to some of the higher moths, than they are to any other butterflies. They are peculiar for their robust body, broad head, hooked antennæ, which are widely separated at base, great length of tongue,

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\* I have given in parenthesis the corresponding "family" groups of Bates (Journ. Ent. I, 219—20), since the arrangement here proposed agrees more closely with his than with that of any other naturalist. The only exception to complete general equivalency is his separation of the Rurales into two families (whereas I look on those divisions as sub-families), and his placing the Libytheidæ as the highest member of his Erycinidæ, while I would place them as the lowest member of the Nymphales.

† I call these typical (as Swainson called them "true butterflies,") because they include the commonest butterflies of the north temperate zone, the white and yellow butterflies, or the insects most familiarly known as butterflies to the world at large.

‡ See the writings of Geoffroy, Fabricius, Leach, Dalman, Latreille, etc.

small wings, and the presence of a middle pair of spurs on the front and hind legs, in the former developed as a curious foliate epiphysis; their eggs are broadly truncate spheres, sometimes ribbed; their caterpillars have a large head, with a very thick skull, a very contracted neck formed of the first body-segment, and bearing a corneous shield above, and a body covered with minute papillæ, bearing microscopic hairs; their chrysalids are smooth and uniform like the pupæ of moths, but in rare instances (e. g. *Calpodes* \*), are pointed in front.

The other three families appear to have diverged simultaneously from each other shortly after their common separation from the skippers. This latter family is the most homogeneous; each of the others comprises a considerable variety of structural types, for which it is difficult, in each case, to find a common expression. The Papilionides however, may be known by the squareness of the head between the eyes, the entire inner margin of the eyes, the diminutive size and frequently lamellar structure of the prothoracic lobes, the acuteness of the front of the meso-scutellum, and the notched or produced, instead of entire, dorsal margin of the eighth abdominal segment of the male; in the entire inner margin of the eye, they agree altogether with the Nymphales, but from these they may also be distinguished by the presence, as in the skippers, of a fourth median nervule on the front wing, or by its entire absence; for in the Nymphales it is always transferred to the sub-costal nervure. There are many other particulars in which the sub-families of Papilionides may be distinguished from all other butterflies, but in which they do not agree together; the same is also true of the sub-families of the higher groups.

The eggs of Papilionides, so far as known, are either nearly globular and smooth, or are ribbed and much higher than broad, and in these respects differ, so far as I am aware, from very nearly all higher butterflies.† The egg of *Parnassius* however, is an extraordinary exception, resembling that of the Lycænids described below. The caterpillars are never spined, but either approximately naked, pilose, or provided with fleshy tubercles or filaments. The chrysalids are hung by a loose girt, and are the only girt chrysalids which have the head armed in front with a single central prolongation or a pair of prominent tubercles.

One characteristic mark of the gossamer-winged butterflies is their

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\* See Dodge in *The Rural Carolinian* III, 594, (1872).

† The egg of *Danaiida Plexippus* and, approximately, those of *Brenthis*, come near the latter class.

ordinarily small size, and to this we may add the tenuity and general delicacy of their structure; their head between the eyes is usually very narrow or twice as high as broad, so that the eyes are approximated, and infringe to such an extent upon the antennal scrobes, as to excise to a greater or less extent their own inner margin; the meta-thorax is less distinctly separated from the meso-thorax than usual; the front wings are pretty uniformly broad, rarely as elongate as in other families, and both wings are entire, excepting when the hind pair is tailed; in the heteromorphous character of the fore legs in the two sexes they may be known from all other butterflies, excepting the very lowest Nymphales (*Libytheidæ*), which, on that account, have been placed with them by Bates and some recent authors.

The transformations of so few of the higher group of this family are known, that it is impossible to make any general statement concerning them. But the eggs of the *Lycænids* or lower sub-family are peculiar for their echinoid or turban-shaped, heavily pitted form, in which respect only *Parnassius* appears to agree with them. The caterpillars are remarkable for their onisciform shape and gliding motion, their nearly aborted pro-legs, the minuteness of their head, and its power of complete concealment within the first body-segment; they are hairy, but never bear spines or filaments. The chrysalids are short and compact, completely rounded and closely attached to the surface by a girt; the cremaster is wanting, and the hooks seated directly upon the last abdominal segment, which, like the head, is completely carried over to the under surface of the body.

Doubtless the early stages of the *Erycinids* agree to a certain extent with those of *Lycænids*, but not altogether, for the only egg known (that of the European species), is described as almost globular and smooth; the head of the caterpillar cannot be so completely withdrawn, and the body is furnished to some extent with filaments or possibly spines and only appears subordinately onisciform. Still, so far as known, the early stages of *Erycinids* agree better with those of *Lycænids* than with any other butterflies, and these features, with the compact form of the chrysalis and its closely girt attachment to its support,\* together with the opposite development of the fore legs in the two sexes of the imago and the close similarity of all other points in the structure of the perfect form, including the absence of the nervule attached in all other butterflies, excepting the *Pierids*, to

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\* According to Bates, the pupa of *Stalactis*, one of the highest *Erycinids*, is "secured rigidly by the tail in an inclined position, without a girdle;" this mode of suspension forms a natural passage to the freely hanging *Nymphales*.

the end of the median nervure of the fore wings, show that no family distinction should be drawn, as has usually been done, between these two groups.\*

In the form of the head, the highest family agrees very well with the Papilionides, although as a rule it is considerably narrower, standing in this respect midway between the two middle families; the inner edge of the eye is entire; the prothoracic lobes are moderately large and tumid, and the nervule, attached to the end of the median nervure of the fore wing in the lowest butterflies, is here transferred to the sub-costal nervure, becoming a second inferior sub-costal nervule, which does not exist as such in any other family. Its presence in all the members of this family warrants the restoration, by Bates, of the ancient limits of this group, which, of recent years, has been torn by systematists into so many fragments. It does not however confirm his removal of the Libytheans to the next lower family, although in one of the most prominent and important features of the Nymphales—the atrophy, though still unequal, of the fore legs of both sexes—the Libytheans show their close relationship to the Erycinids, since the legs of their females are normal.

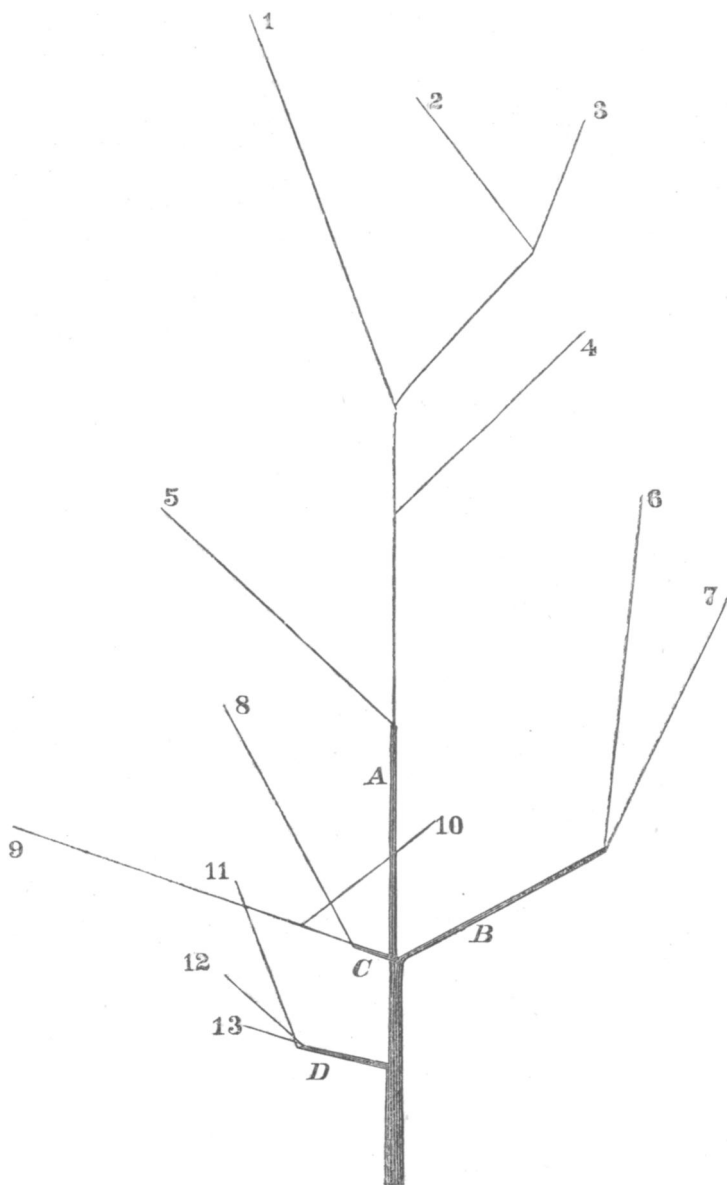
The eggs of the brush-footed butterflies are always either reticulate or ribbed, seldom greatly higher than broad, never smooth, but occasionally so heavily reticulated as rather to be termed pitted; in these cases however, the division walls are extremely thin and never, as in the Lycænids, coarse. The caterpillars are pilose, spinous or armed with filaments or tubercles. The chrysalids never have a perfectly even contour, but show at least some rounded or angulate projections; and usually the head is armed, more or less conspicuously, with a pair of projecting tubercles; they are invariably suspended by the tail alone, or rarely are not suspended at all.

By means of the diagram given on the next page† I have attempted to exhibit the apparent relation of the different groups to each other; the position of the main branches and their divisions is supposed to indicate, on the basis of existing affinities, the relative time at which

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\* Cf. my paper on the structure and transformations of *Eumæus Atala*. Mem. Bost. Soc. Nat. Hist. II, 431 seq. (1875).

† EXPLANATION OF DIAGRAM.—A, Brush-footed Butterflies, *Nymphales*. B, Gosamer-winged Butterflies, *Rurales*. C, Typical Butterflies, *Papilionides*. D, Skippers, *Urbicolas*. 1, Satyrs, *Praetores*. 2, Danaids, *Festivi*. 3, Heliconians, *Heliconiæ*. 4, Nymphs, *Najades*. 5, Snout Butterflies, *Hypati*. 6, Erycinids, *Vestales*. 7, Lycaenids, *Plebeii*. 8, Pierids, *Danai*. 9, Swallow-tails, *Equites*. 10, Parnassians, *Parnasii*. 11, Large Skippers, *Hesperides*. 12, Small Skippers, *Astyci*. 13, *Castnioides*.



the different groups diverged from each other or from the main stem; and the height which each branch attains, the relative perfection of the highest members of that group. It is of course impossible to represent this with any accuracy on a flat surface; for one may properly conceive of a group only as a mass, composed of branches springing from a central core. The Equites and Ephori are thus brought at opposite extremities of the tree, whereas they are closely related to each other and disagree with all other groups, in the retractility of the head of the caterpillar;\* this relationship however is indicated by each occupying the lowest twig of the branch on which it is seated, and both branches being closely connected at their base. The striking and unique peculiarities of certain groups is shown by their extreme divergence from the main stem: thus the Equites or Swallow-tails stand apart from all others in the possession of dorsal osmateria in the caterpillar and in certain special characters of the butterfly, shortly to be mentioned; the Ephori or Lycænids at the opposite extreme, in the onisciform nature and diminutive heads of their caterpillars; the Castnioides among the skippers by their close approach to the moths;† and the Satyrs (Oreades), by the forked tail of their caterpillars; the superficial affinity of this last group to the skippers is also indicated on the diagram by the directness of their line from the very base. It is one of the most curious features in the structure of butterflies that its highest and lowest members should resemble each other in so many minor points. For instance, the tone of coloring and pattern of markings on the wings of many Satyrs, as well as the position and general nature of the sexual marks on the front pair of some males, find a close counterpart on the wings of some skippers; so also the chrysalids of Satyrs are among the simplest, most rounded and compact in the whole family, approaching in this respect the lowest butterflies; nevertheless in all the prime features of their organization, the Satyrs outrank all others or divide the honors with the Danaids.

The Libytheans or snout butterflies are placed at no great distance

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\* I do not know that attention has ever been drawn to this feature in the caterpillars of Equites, since the time of Denis and Schiffermüller, who say (Syst. Verz. Schmett. Wien, 161, 1775), "Diese Raupen . . . ziehen den kleinen stumpfen Kopf gern unter den ersten Ring zurück." When at rest the head is nearly half concealed by the extended epidermis of the first body-segment, and can be compared with nothing in other butterfly caterpillars, excepting the complete retractility of the head in Lycænids.

† Cf. Riley's admirable paper entitled Notes on the Yucca Borer (Trans. Acad. Sc. St. Louis, III, 323 seq.); see also his Reports on the Insects of Missouri, VIII, 169 seq., IX, 129.

from the Pierids, on account of the close resemblance of the caterpillars of the two groups; their position far removed from the other brush-footed butterflies is intended to mark their anomalous structure, while their slight elevation above the Erycinids signifies the nearly equal development of the fore legs in both sub-families. The Parnassians resemble the Lycænids in the egg state, and to a certain extent the Erycinids in their larval state, and are therefore turned toward the Gossamer-winged butterflies, though belonging closely with the Swallow-tails. The resemblance of the egg of the Hesperides and Pierids on the one hand and of the smaller skippers and Swallow-tails on the other is shown by the direction of the branches of the lowest family. By this scheme, all the spinous caterpillars are brought together upon one side, and near together, and all the heteropodous butterflies are carried above the middle.

It may be remarked that, with slight variations, this distribution of the groups of butterflies, founded upon the relative perfection of their organization is generally accepted by the best investigators; and is founded upon a mass of minor features which will not be recounted here. A single exception should however be made in regard to the typical butterflies, whose position is the point of greatest dispute, many continuing to place them highest of all on account of the beauty and special perfection of character of a single member of that family, the group of Swallow-tails. Nothing can exceed the gorgeousness of the huge Ornithopteras of the East Indies, and the most queenly of our own butterflies are their nearest relatives. They also show a unique development, as has been thought, in the diminutive size of the palpi of the imago, in the possession of four branches to the median nervure of the front wing, and in the dorsal and extreme development of osmateria in the caterpillar. But there is no reason whatever for considering the brevity of the palpi or the extra branch of the median nervure marks of high organization. On the contrary, in these very points they resemble the skippers more closely than they do any other butterflies, and these features are therefore traces of their low organization. Indeed the terminal median nervure of the Swallow-tails is the most unstable in its attachments of all the nervules of the fore wing; it appears to belong decidedly to the median nervure only in the Swallow-tails, but there can really be no doubt that it is a part of the same nervure in the skippers; while in the Nymphales it has simply transferred its allegiance to the sub-costal nervure; and if it exist at all in the Rurales, which we doubt, it is the nervule usually connected with both nervures by an equally obsolete vein, but be-



longing properly to the sub-costal, of which it is the only inferior branch.

The possession of the peculiar scent organ, however, is unquestionably a mark of high development. Wallace writes:\* "When we consider this singular apparatus, which in some species is nearly half an inch long, the arrangement of muscles for its protrusion† and retraction, its perfect concealment during repose, its blood-red color, and the suddenness with which it can be thrown out, we must, I think, be led to the conclusion that it serves as a protection to the larva, by startling and frightening away some enemy when about to seize it, and is thus one of the causes which has led to the wide extension and maintained the permanence of this now dominant group. Those who believe that such peculiar structures can only have arisen by very minute successive variations, each one advantageous to its possessor, must see, in the possession of such an organ by one group, and its complete absence in every other, a proof of a very ancient origin and of very long-continued modification. And such a positive structural addition to the organization of the family, subserving an important function, seems to me alone sufficient to warrant us in considering the Papilionidæ as the most highly developed portion of the whole order, and thus in retaining it in the position which the size, strength, beauty, and general structure of the perfect insects have been generally thought to deserve."

It is unphilosophical, however, to accord high rank to any group for a single characteristic, and especially when in nearly all its other important peculiarities, it evinces its low origin. Moreover extensive fleshy organs do occur in other groups.‡ Guenée discovered them on the abdominal segments of the caterpillars of certain blues,§ and caruncles, as they are called, entirely similar to osmateria in function, general structure and degree of development, occur in single genera of beetles,|| while totally absent from their nearest allies; yet nobody

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\* Wallace, Natural Selection Am. Ed. 135. It may be remarked that in his recent work on Geographical Distribution, Wallace has abandoned his former position and accepted the arrangement proposed by Bates.

† Protrusion is probably effected by mere contraction of the body-walls, which fills the osmateria with the fluids of the body.

‡ I have elsewhere maintained that the ventral sac on the first body-segment of butterfly larvæ is essentially homologous with the osmateria. See *Psyche* I, 168.

§ *Ann. Soc. Ent. France*, (4), VII, 665 seq. (1867).

|| Malachius et al. See Siegel. Ueber den Ausstülpungs-Apparat von Malachius und verwandten Formen 8<sup>c</sup> Hannover, 1873.

on that account claims for them a high rank. In the larva of *Cerura* we find a much more extraordinary special development than the caterpillars of the Swallow-tails can boast; the anal prolegs become long, cylindrical tubes, extending backward and upward, from out of which when provoked, the caterpillar thrusts a highly colored and banded fleshy tentacle, with which it lashes its body to frighten away intruders. Yet in other points of its structure it perfectly agrees with its kindred. Then again if we examine the lips of the closed osmateria of the Swallow-tails, we shall find them of a corneous nature, resembling no other feature in butterfly larvæ than the chitinous dorsal shield on the first segment of the caterpillars of skippers; we have therefore in the osmateria themselves indications of a low origin, a relationship with the skippers which most other points in the structure of the Swallow-tails exhibit. The recurved club of the antenna recalls most strikingly the structure of the antennal tip of the higher skippers\* and are unlike those of any other group of butterflies. The inner border of the hind wing also is folded longitudinally just as it always is in the skippers and rarely in other butterflies; moreover this fold is utilized in many males for the concealment of peculiar sexual hairs, and thus becomes very similar to the costal fold on the fore wings of many male *Hesperides*, and quite unlike anything else in other butterflies. But perhaps the most striking point of affinity between these two groups lies in the possession, on the front tibiæ, of the same characteristic foliate epiphysis, which is wanting in all other butterflies;† this, like the possession in skippers of two pair of spines on the hind tibiæ is certainly a mark of degradation, by which they are allied to the lower families of *Lepidoptera*. The eggs of the Swallow-tails, so far as known, are subspherical with a flattened base and almost absolutely smooth, in which they are unlike the eggs of any other butterflies excepting those of the *Astyci* among the skippers (and excepting, perhaps, that of *Nemeobius*), while those of the *Pierids* have closer resemblance to the eggs of *Hesperides*.‡ We find therefore that in the very peculiarities of their structure wherein they depart from the higher butterflies, they are most closely related to the skippers.

But again the Swallow-tails are universally conceded to be so closely allied to the *Pierids* that they are invariably placed next them; con-

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\* Compare, for example, the antennæ of *Iphiclides Ajax* and *Hesperia ruralis*.

† Cf. Speyer, Oken's *Isis*, 1843, 166.

‡ See my paper on the two principal groups of *Urbicolæ*. *Bull. Buff. Soc. Nat. Sc. I*, 195—6.

sequently if the Swallow-tails are placed highest in the scale, the Pierids must go with them; nobody questions this; *yet the Pierids possess not a single one of the characteristics by which a high rank is claimed for the Swallow-tails.* Commentary upon this is needless.

Further than this, in several features now to be mentioned, we may trace a regular progression in passing from the lower to the higher butterflies. These features indicate with little doubt the actual progress of events in the geologic history of higher lepidopterous life, and leave a record of advance which is completely falsified by removing the Swallow-tails to the summit of the order. Attention has been drawn to one of these features by Bates, who, at the same time proposed one of the most rational systems yet advanced;\* it has however been known and used in dividing butterflies since the time of Linné and Geoffroy.† I refer to the structure of the legs, where fundamental distinctions occur among butterflies. In the lowest family or skippers, as in the moths, all the legs are developed to an equal extent; they only differ in proportional length. In the Swallow-tails and in all the other members of the family of Papilionidæ this also is true. But the moment we leave these two lower families, a change appears in the front legs and progresses regularly. In the gossamer-winged butterflies all the legs of the females are alike, but the front pair of the male is variously aborted; in the Lycænids the tarsi of this sex have lost the terminal claws and are densely spined beneath; even within this group we can trace gradations, the claws being first replaced by a single curving spine, and then by a pair of straight spines only a little longer than the others; in the Erycinids, the tarsi are spineless, and the joints are reduced from five to two or even one. In the highest family, the brush-footed butterflies, atrophy of the fore legs has reached both sexes, so that they are practically useless, although the atrophy is much more excessive in the male; the legs of the female are greatly reduced in size, and lack the terminal armature; while in the male of the highest groups, they are exceedingly diminutive, and the tarsi are reduced to a single minute joint. Now when we remember that this atrophy affects only the legs borne by

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\* Journ. Ent. I, 218—22. (1861); II, 175—77, (1864); Trans. Linn. Soc. Lond. XXIII, 515, (1862).

† See particularly Dalman's admirable paper: Forsök till systematisk Uppställning af Sveriges Fjarilar, (Vetensk. Acad. Handl. XXXVII, 48 seq. 1816); or the abstract of it in Oken's Isis, (1824, 416 seq.). His classification has been pretty closely followed by his countryman Wallengren, (Lepidopt. Scand. Rhop. 8° Malmö, 1853).

the first segment of the thorax, and that this very segment and this only in passing from the low larval stage to the perfect form has become greatly reduced in size, we must accept atrophy of *these* legs as a conclusive mark of high organization.

If again we examine the tongue, we shall find, as we pass upward, a regular increase of complication in the structure of the papillæ or organs of taste; at least this is true in the fifty or sixty species I have examined. In the Swallow-tails and their allies, as in the skippers, these papillæ are merely minute distant tubercles, situated near the tip, half a dozen or less on either side, seldom rising much above the surface. In the gossamer-winged butterflies they are longer, much more frequent and often mammilate at the tip. While in the brush-footed butterflies they are crowded closely together, are often half the breadth of the tongue in length and frequently trifid or tri-mammilate at their tip.

Finally, how do the modes of transformation affect the question? The moths, as a general rule, pass their chrysalis stage in a cocoon of silk or earth, in which they lie loosely in a horizontal position. The skippers also undergo their transformations in a cocoon, a light fragile affair it is true, but still unquestionable a cocoon; one or two other butterflies also make a slight cocoon, wherein to change to chrysalis; and these few instances, such as *Parnassius* and *Zegris*, belong exclusively to the same family as the Swallow-tails, though not to the same precise division.\* The skippers, however, do not lie loosely in their cocoons, as do the pupæ of moths, but spin at either end a Y-shaped thread, into the centre of one of which they plunge their hooked cremaster, while in the upper loop of the other they rest their body. Now when we reach the next family, the typical butterflies, the cocoon, save in the exceptional instances mentioned, is lost, while the silken attachments of the chrysalis still remain, modified to suit the circumstances. Instead of the Y-shaped band, wherein to plunge the cremaster, a carpet of silk is woven upon some branch, into the midst of which the hooks are thrust, while the omission of the stem of the other Y leaves a loop or girt about the middle. To accommodate the chrysalis thus hung next a solid substance, instead of in the middle of an oval cell, the segments of the abdomen must curve upward to-

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\* Mr. W. H. Edwards (Trans. Am. Ent. Soc. VI. 3), endeavors to explain this cocoon in *Parnassius* as a "biological necessity" from its exposed position on Alpine heights; probably he was not aware of the occurrence of the cocoon in *Zegris*, which is common on the plains of Southern Spain. See Rambur, Faun. Ent. Andal. II, 247, pl. 11, fig. 4.

ward the ventral line (for the chrysalis lies upon its back), and thus the ventral outline becomes straight, while the dorsal is strongly arched. This condition of things is perpetuated and often intensified in the next higher family, the gossamer-winged butterflies, which differ in this respect from the typical butterflies only in the closer binding of the girt around the middle. In the highest family, the brush-footed butterflies, the girt around the middle is lost and the chrysalis hangs suspended by the tail alone. We see therefore a regular progression from the lower to the higher butterflies, in the loss first of the cocoon, next of the girt; and as if this were not enough, some of the highest butterflies\* have even lost the last remnant of silk and fallen to the earth, where, amid stubble or in crevices in the ground, they undergo their transformations without more ado. As if moreover to show that this suspension of the chrysalis by the tail alone is a stage beyond that of hanging by tail and girth, we have a clear proof that all the suspensi, as Boisduval happily calls them, have passed through the stage of the succincti, since *the straight ventral surface of the abdomen*, assumed perforce by the succincti, when they left the cocoon stage and became attached to hard surfaces, *still remains in the chrysalis of the brush-footed butterflies, where it no longer serves any purpose*,—as clear and striking an indication that the suspensi outrank the succincti, as that the pupa is higher than the larva.

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\* *Oeneis semidea*, *Agapetes Galathea*, *Nytha Circe* and *Eumenis Semele*.